AD-A051 359 NAVY ELECTRONICS LAB SAN DIEGO CALIF F/G 17/1

DESCRIPTION OF 23-BEARING 39-BEAM BROAD BAND INDUCTIVE PHASE CO--ETC(U)

MAY 64 J A PEUGH

UNCLASSIFIED NEL-TM-694 NL

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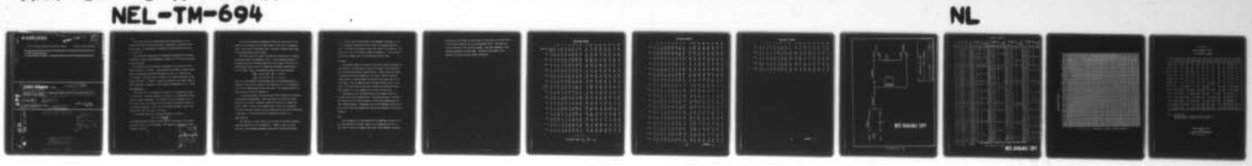

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NEL/Technical Memorandum 694

TECHNICAL MEMORANDUM TM-694 (14) NEL-TM-694

DESCRIPTION OF 23-BEARING 39-BEAM BROAD BAND INDUCTIVE PHASE COMPENSATOR FOR 16 ELEMENT LINE ARRAY

21 May 1964 (12) 12P.

James A. Peugh (Code 3130)

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253 550 JOB

This report gives the specifications and design details of the second broad band inductive beam former constructed for NEL Code 3130 for use with a 16 hydrophone, 23 bearing line array system for use at 50 to 500 cps.

The device was constructed by Instruments Incorporated, San Diego, California, Contract N123(953)33858A, primarily for use with towed sonar receiving arrays.

The inductive broad band phase compensator is introduced in NEL Report 1009 by F. R. Abbott. The theory and performance of phase compensators is discussed in several NEL Reports by Dr. C. J. Krieger and R. P. Kempff. The most useful of these is the Linear Array part of NEL Report 1108 by R. P. Kempff. A memo which describes the first inductive broad band phase compensator is NEL Technical Memorandum 614 by J. Peugh.

BEAM FORMATION

The beam former is designed for an array of 16 hydrophones spaced six feet apart. The beam formation is done in a 16 transformer 39-beam inductive phase compensator. The primary of each transformer has 600 turns with a tap at 100 turns for use with the low impedance output of the matching amplifier. There are 78 secondary windings on each transformer which vary from +10 to -10 turns.

The shading factor A_n, for any hydrophone, is given by

$$A_n = 10 \cos |8-n| / 7.1$$

where $|8-n|$ indicates absolute value, and n is the number of the hydrophone from either end of the array. The shading is introduced on the secondary windings.

The winding schedule is designed so that the center point of the array would correspond to $+45^\circ$ phase shift if there were a hydrophone there. This choice is arbitrary and it produced a symmetry that makes the winding schedule easy to check.

For equal cross-over beams, the beams are separated by a constant incremental phase per hydrophone, 11.8°. So the winding schedule is calculated from the following equations in which QS_{nm} is the number of sine-winding turns in the n'th transformer secondary contributing to the m'th beam. QC_{nm} is corresponding number for cosine windings:

$$QS_{nm} = A_n \operatorname{Sin} (45+ \; 8\tfrac{1}{2} - n \;\; 11.8 \; m \;)$$

$$QC_{nm} = A_n \operatorname{Cos} (45+ \; 8\tfrac{1}{2} - n \;\; 11.8 \; m \;)$$

where n is the number of the hydrophone with the forward hydrophone numbered 1, and m is the number of the beam from 14 to -14 including 0, and A_n is the shading factor mentioned above. The winding schedule for QS_{nm} and QC_{nm} is given in Appendix 1.

The summing networks for the sine and cosine windings were designed by Instruments Incorporated. These each feed a one 1000 ohm filter. There are 201 filters. Appendix 2 shows the circuit of a summer and filter. Beam + 15 and -15 are summed with a center tap transformer. The inter connection between the beam former and the filters are described in Appendix 3. The filters have an attenuation of about 7 db.

BEAM DIRECTION

The selection of which beam to use for each of the beam, frequency pairs was made by the use of Appendix 4. Using a filter for every direction, and frequency combination would have required 299 filters.

using a filter only for the nearest beam frequency combination, saves 98 low frequency filters and doesn't effect the bearing resolution since the broader low frequency beams cover many of the bearings. The beams chosen for each bearing is shown in Appendix 5. The bearings on the sealecto board cross over at less than three db down.

OPERATION

The sealecto board on the front of the beam former is composed of two sections. The top section connects the output of the filters to the corresponding bearing, frequency pairs. These points are bussed vertically as pairs are inserted in the board. These 23 vertical busses connect to the 23 output connectors on the right side of the beam former. The 23 busses continue through the bottom half of the board. The bottom half of the board contains ten horizontal busses that connect to the ten outputs on the bottom of the board.

Inserting a pin in the bottom half of the board connects its vertical bus to its horizontal bus. Inserting two pins on the same horizontal bus on the lower section, ties the two corresponding vertical busses together. Inserting a pin in two different points driven by the same filter also shorts the vertical bus of each of the points together.

GAIN

The voltage gain of the system with the amplifier setting on 10 is 10 db; amplifier setting 1, gain -10 db; amplifier setting .1, gain -30 db. This gain compares the input to the impedance matching

amplifiers to the output of beam former at the center of the main lobe, at the center frequency of the corresponding filter. This does not include the gain of the low level preamp. The input impedance of the matching amplifier is 10,000 ohms. An input of two volts is the maximum the system can take without distortion.

Hydrophone Number

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Beam 19 -	Sin	0	1	-5	6	-3	-4	9	-9	4	4	-8	8	-3	-2	3	-1
	Cos	-1	3	-2	-3	8	-8	4	4	-9	9	-4	-3	6	-5	1	0
18 -	S	-1	3	-4	2	3	-7	10	-9	5	1	-6	8	-7	4	-1	-1
	C	-1	-1	4	-7	8	-6	1	5	-9	10	-7	3	2	-4	3	-1
17 -	S	0	0	2	-4	7	-9	10	-8	6	-2	-1	4	-5	5	-3	1
	C	1	-3	5	-5	4	-1	-2	6	-8	10	-9	7	-4	2	0	0
16 -	S	1	-3	5	-7	8	-9	8	-8	6	-5	3	-2	0	1	-1	1
	C	1	-1	1	0	-2	3	-5	6	-8	8	-9	8	-7	5	-3	1
15 -	S	1	-2	3	-4	5	-6	6	-7	7	-7	7	-7	6	-4	3	-1
	C	-1	3	-4	6	-7	7	-7	7	-7	6	-6	5	-4	3	-2	1
14 -	S	-1	2	-3	2	-1	-2	4	-6	8	-9	9	8	6	-4	2	-1
	C	-1	2	-4	6	-8	9	-9	8	-6	4	-2	-1	2	-3	2	-1
13 -	S	-1	3	-5	6	-6	3	1	-5	8	-10	9	-6	2	1	-2	1
	C	1	-2	1	2	-6	9	-10	8	-5	1	3	-6	6	-5	3	-1
12 -	S	1	-1	-1	6	-8	7	-2	-4	9	-10	6	0	-4	5	-3	1
	C	1	-3	5	-4	0	6	-10	9	-4	-2	7	-8	6	-1	-1	1
11 -	S	1	-3	4	0	-6	9	-5	-3	9	-9	2	5	-7	3	0	-1
	C	-1	0	3	-7	5	2	-9	9	-3	-5	9	-6	0	4	-3	1
10 -	S	-1	0	5	-5	-1	9	-7	-2	10	-7	-3	8	-4	-2	3	-1
	C	-1	3	-2	-4	8	-3	-7	10	-2	-7	9	-1	-5	5	0	-1
9 -	S	-1	3	0	-7	4	6	-9	-1	10	-4	-7	7	2	-5	1	1
	C	1	1	-5	2	7	-7	-4	10	-1	-9	6	4	-7	0	3	-1
8 -	S	1	2	-5	-2	8	2	-10	-1	10	-1	-9	2	6	-2	-3	1
	C	1	-3	-2	6	2	-9	-1	10	-1	-10	2	8	-2	-5	2	1
7 -	S	1	-2	-4	4	7	-3	-10	1	10	2	-9	-3	6	3	-2	-1
	C	-1	-2	3	6	-3	-9	2	10	1	-10	-3	7	4	-4	-2	1
6 -	S	-1	-3	1	7	3	-7	-9	2	10	5	-6	-7	1	5	2	-1
	C	-1	2	5	1	-7	-6	5	10	2	-9	-7	3	7	1	-3	-1
5 -	S	-1	1	5	5	-3	-9	-7	3	10	7	-2	-8	-5	1	3	1
	C	1	3	1	-5	-8	-2	7	10	3	-7	-9	-3	5	5	1	-1
4 -	S	1	3	3	-1	-7	-9	-4	4	9	9	3	-4	-7	-4	0	1
	C	1	0	-4	-7	-4	3	9	9	4	-4	-9	-7	-1	3	3	1

APPENDIX I

"SECONDARY TURNS QS_{nm} AND OC_{nm}

Hydrophone Number

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3 -	S	1	0	-3	-6	-8	-6	-1	5	9	10	7	2	-3	-5	-3	-1
	C	-1	-3	-5	-3	2	7	10	9	5	-1	-6	-8	-6	-3	0	1
2 -	S	-1	-3	-5	-6	-5	-2	2	5	8	10	9	6	3	0	-1	-1
	C	-1	-1	0	3	6	9	10	8	5	2	-2	-5	-6	-5	-3	-1
1 -	S	-1	-2	-2	-1	1	2	4	6	8	9	9	8	7	5	3	1
	C	1	3	5	7	8	9	9	8	6	4	2	1	-1	-2	-2	-1
0 -	S	1	2	4	5	6	6	7	7	7	7	6	6	5	4	2	1
	C	1	2	4	5	6	6	7	7	7	7	6	6	5	4	2	1
-1 -	S	1	3	5	7	8	9	9	8	6	4	2	1	-1	-2	-2	-1
	C	-1	-2	-2	-1	1	2	4	6	8	9	9	8	7	5	3	1
-2 -	S	-1	-1	0	3	6	9	10	8	5	2	-2	-5	-6	-5	-3	-1
	C	-1	-3	-5	-6	-5	-2	2	5	8	10	9	6	3	0	-1	-1
-3 -	S	-1	-3	-5	-3	2	7	10	9	5	-1	-6	-8	-6	-3	0	1
	C	1	0	-3	-6	-8	-6	-1	5	9	10	7	2	-3	-5	-3	-1
-4 -	S	1	0	-4	-7	-4	3	9	9	4	-4	-9	-7	-1	3	3	1
	C	1	3	3	-1	-7	-9	-4	4	9	9	3	-4	-7	-4	0	1
-5-	S	1	3	1	-5	-8	-2	7	10	3	-7	-9	-3	5	5	1	-1
	C	-1	1	5	5	-3	-9	-7	3	10	7	-2	-8	-5	1	3	1
-6-	S	-1	2	5	1	-7	-6	5	10	2	-9	-7	3	7	1	-3	-1
	C	-1	-3	1	7	3	-7	-9	2	10	5	-6	-7	1	5	2	-1
-7-	S	-1	-2	3	6	-3	-9	2	10	1	-10	-3	7	4	-4	-2	1
	C	1	-2	-4	4	7	-3	-10	1	10	2	-9	-3	6	3	-2	-1
-8-	S	1	-3	-2	6	2	-9	-1	10	-1	-10	2	8	-2	-5	2	1
	C	1	2	-5	-2	8	2	-10	-1	10	-1	-9	2	6	-2	-3	1
-9-	S	1	1	-5	2	7	-7	-4	10	-1	-9	6	4	-7	0	3	-1
	C	-1	3	0	-7	4	6	-9	-1	10	-4	-7	7	2	-5	1	1
-10-	S	-1	3	-2	-4	8	-3	-7	10	-2	-7	9	-1	-5	5	0	-1
	C	-1	0	5	-5	-1	9	-7	-2	10	-7	-3	8	-4	-2	3	-1
-11-	S	-1	0	3	-7	5	2	-9	9	-3	-5	9	-6	0	4	-3	1
	C	1	-3	4	0	-6	9	-5	-3	9	-9	2	5	-7	3	0	-1
-12-	S	1	-3	5	-4	0	6	-10	9	-4	-2	7	-8	6	-1	-1	1
	C	1	-1	-1	6	-8	7	-2	-4	9	-10	6	0	-4	5	-3	1
-13-	S	1	-2	1	2	-6	9	-10	8	-5	1	3	-6	6	-5	3	-1
	C	-1	3	-5	6	-6	3	1	-5	8	-10	9	-6	2	1	-2	1
-14-	S	-1	2	-4	6	-8	9	-9	8	-6	4	-2	-1	2	-3	2	-1
	C	-1	2	-3	2	-1	-2	4	-6	8	-9	9	8	6	-4	2	-1

Hydrophone Number

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
-15-	S	-1	3	-4	6	-7	7	-7	7	-7	6	-6	5	-4	3	-2	1
	C	1	-2	3	-4	5	-6	6	-7	7	-7	7	-7	6	-4	3	-1
-16-	S	1	-1	1	0	-2	3	-5	6	-8	8	-9	8	-7	5	-3	1
	C	1	-3	5	-7	8	-9	8	-8	6	-5	3	-2	0	1	-1	1
-17-	S	1	-3	5	-5	4	-1	-2	6	-8	10	-9	7	-4	2	0	0
	C	0	0	2	-4	7	-9	10	-8	6	-2	-1	4	-5	5	-3	1
-18-	S	-1	-1	4	-7	8	-6	1	5	-9	10	-7	3	2	-4	3	-1
	C	-1	3	-4	2	3	-7	10	-9	5	1	-6	8	-7	4	-1	-1
-19-	S	-1	3	-2	-3	8	-8	4	4	-9	9	-4	-3	6	-5	1	0
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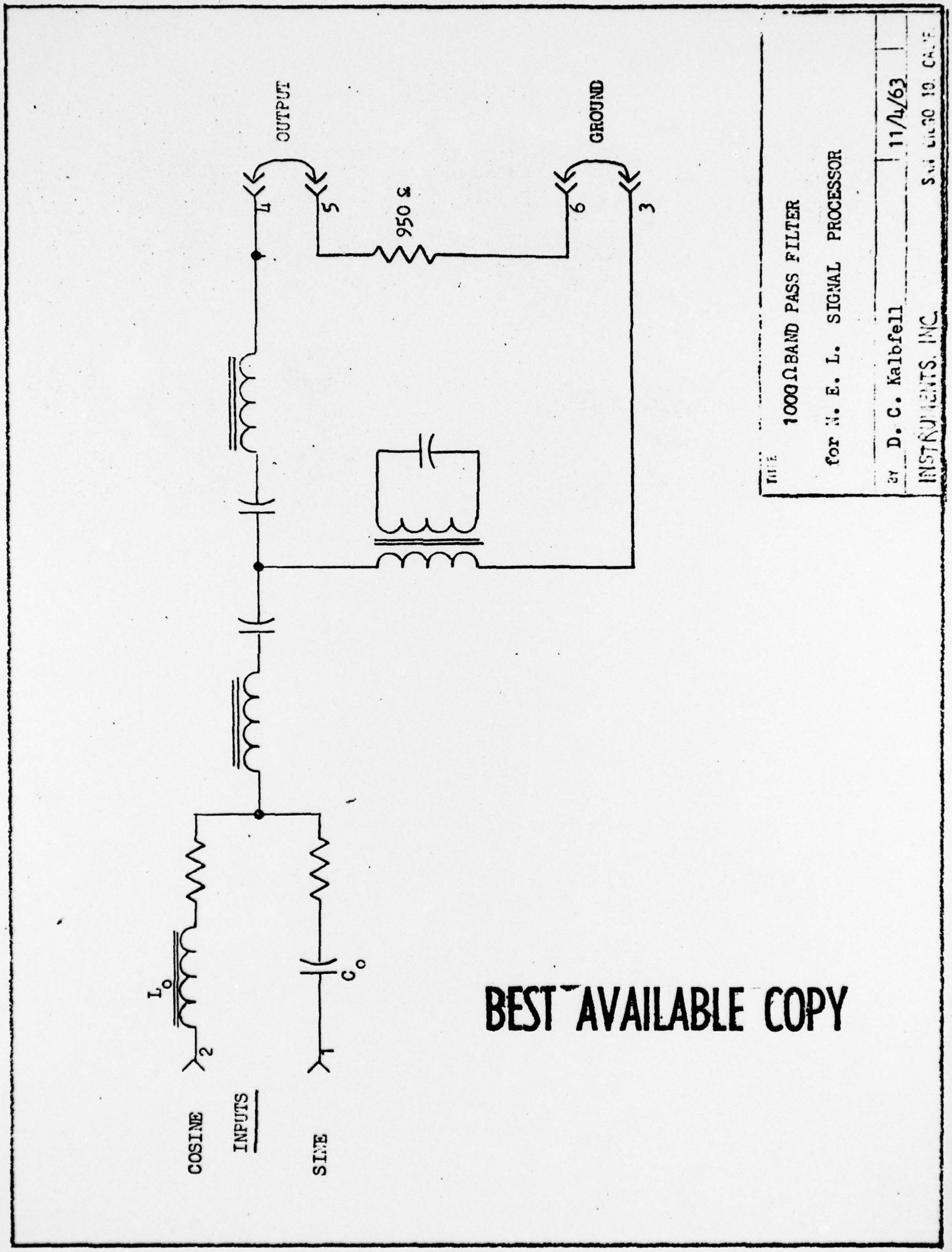

OUTPUT
GROUND
4
5
6
3
950 Ω
L_0
C_0
2
1
COSINE
INPUTS
SINE
1000 Ω BAND PASS FILTER
for N. E. L. SIGNAL PROCESSOR
BY D. C. Kalbfell
11/4/63
INSTRUMENTS, INC.

APPENDIX II

WIRING SCHEDULE

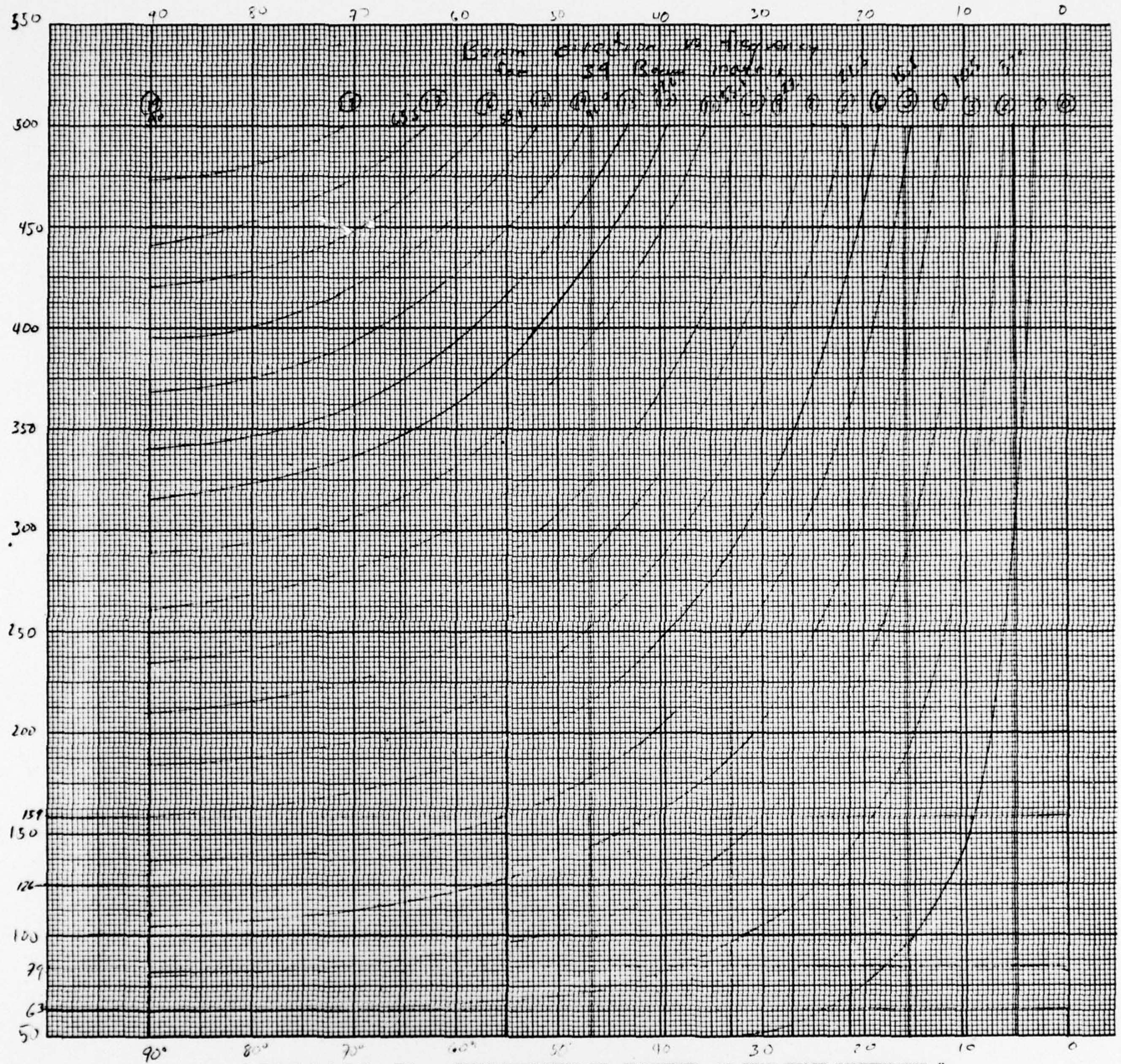
OUTPUT		ROW	DRAWER A			DRAWER B			DRAWER C			DRAWER D		
PIN	COLOR		FILTER		PIN # S C	FILTER		PIN # S C	FILTER		PIN # S C	FILTER		PIN # S C
B- 1	BLACK	A 1	500- 1	19	1 B D	250- 6	5	3 B D	200-17	.0	3 B D	350-15	- 5	1 B D
D- 1	BROWN	2	500- 2	17	1 F H	200- 4			159-13			300-16		
F- 1	BLACK	3	450- 1			159- 2			126- 9			250-15		
H- 1	RED	4	500- 3	16	3 B D	400- 8	4	3 F H	100- 0			200-13		
A- 2	BLACK.	5	450- 2			350- 9			79- 7			159-11		
C- 2	ORANG	6	400-22	15	3 F H	300- 8			63- 5			450-15	- 6	1 F H
E-2	BLACK	7	500- 4	14	5 B D	250- 7			50- 5			400-14		
G- 2	YELLO	8	450- 3			200- 5			400-11	- 1	3 F H	350-16		
B- 3	BLACK	9	400- 1			159- 3			350-12			300-17		
D- 3	GREEN	10	350- 1	13	5 F H	126- 1			300-12			250-16		
F- 3	BLACK	B 1	500- 5	12	7 B D	100- 1			250-11			200-14		
H- 3	BLUE	2	450- 4			500-10	3	7 B D	200- 9			159-12		
A- 4	BLACK	3	400- 2			450-10			159- 7			500-15	- 7	3 B D
C- 4	White	4	350- 2			400- 9			126- 5			400-15		
E- 4	BROWN	5	450- 5	11	7 F H	300- 9			100- 5			350-17		
G- 4	RED	6	400- 3			250- 8			79- 4			300-18		
B- 5	BROWN	7	350- 3			200- 6			63- 3			250-17		
D- 5	ORANG	8	300- 1			159- 4			50- 3			200-15		
F- 5	BROWN	9	500- 6	10	9 B D	126- 2			500-12	-2	7 B D	450-16	- 8	3 F H
H- 5	YELLO	10	400- 4			100- 2			450-12			400-16		
A- 6	BROWN	C 1	350- 4			79- 1			350-13			350-18		
C- 6	GREEN	2	300- 2			500-11	2	7 F H	300-13			300-19		
E- 6	BROWN	3	250- 1			450-11			250-12			250-18		
G- 6	BLUE	4	500- 7	9	9 F H	350-10			200-10			200-16		
B- 7	BROWN	5	450-6			300-10			159- 8			500-16	-9	5 B D
D- 7	WHITE	6	300- 3			250- 9			126- 6			450-17		
F- 7	RED	7	250- 2			200- 7			100- 6			300-20		
H- 7	ORANG	8	450- 7	8	11 B D	159- 5			79- 5			250-19		
A- 8	RED	9	400- 5			126- 3			63- 4			500-17	-10	5 F H
C- 8	YELLO	10	350- 5			100- 3			50- 4			400-17		
E- 8	RED	D 1	300- 4			79- 2			500-13	-3	7 F H	350-19		
G- 8	GREEN	2	250- 3			63- 1			450-13			300-21		
B- 9	RED	3	200- 1			50- 1			400-12			250-20		
D- 9	BLUE	4	500- 8	7	11 F H	400-10	1	9 B D	300-14			450-18	-11	7 B D
F- 9	RED	5	400- 6			350-11			250-13			400-18		
H- 9	WHITE	6	350- 6			300-11			200-11			350-20		
A-10	ORANG	7	300- 5			250-10			159- 9			300-22		
C-10	GREEN	8	250- 4			200- 8			126- 7			500-18	-12	7 F H
E-10	ORANG	9	200- 2			159- 6			100- 7			450-19		
G-10	BLUE	10	450- 8	6	13 B D	126- 4			79- 6			400-19		
B-11	ORANG	E 1	400- 7			100- 4			400-13	-4	9 B D	350-21		
D-11	WHITE	2	350- 7			79- 3			350-14			350-22	-13	9 B D
F-11	YELLOW	3	300- 6			63- 2			300-15			500-19	-14	9 F H
H-11	GREEN	4	250-5			50- 2			250-14			450-20		
A-12	YELLO	5	200- 3			500-23	0	9 F H	200-1[illegible]			400-20		
C-12	BLUE	6	159- 1			450-22			159-10			400-21	-15	11 B D
E-12	YELLO	7	500- 9	5	13 F H	400-23			126- 8			500-20	-16	11 F H
G-12	WHITE	8	450- 9			350-23			100- 8			450-21		
B-13	GREEN	9	350- 8			300-23			500-14	-5	9 F H	500-21	-17	13 B D
D-13	BLUE	10	300- 7			250-21			450-14			450-22		

F-13 GREEN GROUND

H-13 WHITE GROUND

"INTERCONNECTION SCHEDULE FOR FILTERS AND BEAM FORMER."

APPENDIX III



APPENDIX IV. "BEAM DIRECTION VS. FREQUENCY 39 BEAM PHASE COMPENSATOR."

APPENDIX 5

BEAM ASSIGNMENT CHART
for
23 OUTPUTS, 39 BEAMS

	90°	65.5°	55.1	46.7	39.6	33.1	27.1	21.3	15.8	10.5	5.2	0	-5.2	-10.5
500	19	17	16	14	12	10	9	7	5	3	2	0	-2	-3
450	17	16	14	12	11	9	8	6	5	3	2	0	-2	-3
400	15	14	12	11	10	8	7	6	4	3	1	0	-1	-3
350	13	12	11	10	8	7	6	5	4	2	1	0	-1	-2
300	11	10	9	8	7	6	5	4	3	2	1	0	-1	-2
250	10	9	8	7	6	5	4	3	3	2	1	0	-1	-2
200	8	7	6	6	5	4	3	3	2	1	1	0	-1	-1
159	6	5	5	4	4	3	3	2	2	1	1	0	-1	-1
126	5	4	4	3	3	3	2	2	1	1	0	0	0	-1
100	4	3	3	3	2	2	2	1	1	1	0	0	0	-1
79	3	3	3	2	2	2	1	1	1	1	0	0	0	-1
63	2	2	2	2	1	1	1	1	1	0	0	0	0	0
50	2	2	2	1	1	1	1	1	1	0	0	0	0	0

Total: 201 filters
Maximum number of outputs from one filter: 6
Maximum number of filters from one beam: 13

BEAM SELECTION CHART
FOR
39 BEAM PHASE COMPENSATOR
APPENDIX V.